TABLE OF CONTENTS

CONFIDENTIAL

Phase I Final Report

25X1

This report discusses the design and development of a combination micro-stereoscope and binocular microscope as specified in contract #4174. Three objectives have been met in the design of this instrument.

1. Ease of manufacturing to assure reasonable cost.

2. High quality performance.

3. Ease of operation.

We believe that the design objectives have been accomplished and that the additional features which we have added will yield a high quality system capable of performing all of the requirements.

CONFIDENTIAL

DEFINITION OF TERMS USED IN THIS REPORT

1. Micro-stereoscope:

This term is used to indicate that the instrument is utilizing both the right and left optical paths at the same time. Each system viewing a separate image and each eye viewing its respective image.

2. Binocular Microscope:

This term is used to indicate that only one arm and one optical system is being used, but that each eye is viewing the same image simultaneously. In this mode either the right or left optical system may be used.

3. Co-ordinates:

Two co-ordinates are mentioned in this report, they are X and Y respectively.

X Co-ordinates indicates ↔

Y Co-ordinates indicates ↕

X: 2" to 22"

Y: 0" to 15"

DEFINITION OF TERMS USED IN THIS REPORT

4. Image Rotation:

The term "image rotation" is always meant to mean by optical accomplishment and to the section of the optical path containing the Pechan prism.

5. Arm:

When the term "arm" appears, it refers to the lower portion of the microscope that contains the 1X objective and where the 2X and 4X objectives thread in. These arms pivot around to give the desired distances in the X and Y co-ordinates.

6. Working Distance:

This is the minimum distance between the lens objective and the object plane. This distance is measured from the maximum metal protrusion and not from the vertex of the lens.

7. Object Size:

The term "object size" defines the total size which the objective will cover. This size will vary depending upon the objective and magnification range selected.

FIRST ORDER SYSTEM

Table I shows the object size, magnifications, and numerical apertures for each objective throughout the zoom range.

The original working distance of 2", for the 4X objective, has been reduced to approximately .5", by request of the technical representative. This reduced the total height of the instrument so that the user can sit comfortably at the light table.

The schematic shown on Page 5 represents the optical system starting from the object plane.

1. Interchangeable 2X and 4X objectives.
2. 1st surface mirror (may be replaced by a prism to prevent dust and dirt from entering the unit).
3. A fixed 1X objective (not removable from arm housing).
4. 1st surface mirror.
5. 1st surface mirror.
6. 1st surface mirror.
7. Zoom system.
8. 1st surface mirror (this mirror is used to switch to the photographic mode).

CONFIDENTIAL

FIRST ORDER SYSTEM

The above portion is common to all modes of operation.

When the visual mode is used, the optical path continues as follows (from 1st surface mirror No. 8 listed above).

9. Pechan prism.
10. Field lens.
11. Switching prism cluster (this prism cluster is used to change from the micro-stereoscope mode to the binocular microscope mode, and in the binocular mode to either arm).
12. Plano glass plate (used to seal against dust and dirt).
13. Relay lens.
14. Porro prism.
15. Eyepieces, 10X wide field.

When the photographic mode is used, the light path is diverted at the 1st surface mirror No. 8 and continues as follows:

16. 1st surface mirror.
17. 1st surface mirror.
18. Camera lens.
19. 1st surface mirror
20. Camera film plane (Polaroid Film pack adapter).

CONFIDENTIAL

CONFIDENTIAL

ZOOM POSITIONS

SHOWING OBJECT SIZE, NUMERICAL APERTURE

AND MAGNIFICATION USING 10X WIDE FIELD EYEPIECE

Objective 4X	1X	2X	4X
Object Size	4.5mm ∅	2.25mm ∅	1.125mm ∅
Numerical Aperture	.075	.15	.3
Magnification	40X	80X	160X

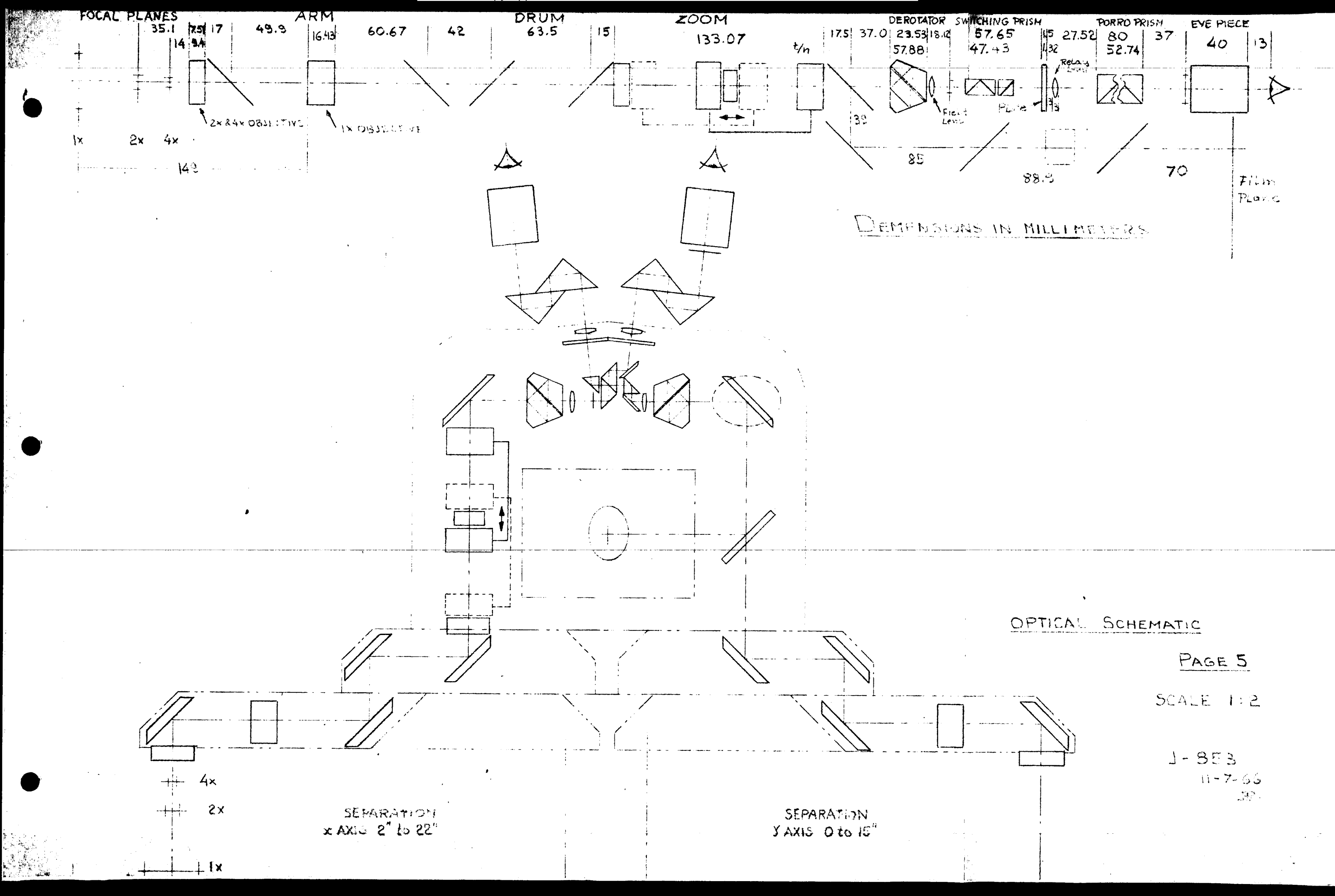
Objective 2X	1X	2X	4X
Object Size	9.0mm ∅	4.5mm ∅	2.25mm ∅
Numerical Aperture	.0375	.075	.15
Magnification	20X	40X	80X

Objective 1X	1X	2X	4X
Object Size	18.0mm ∅	9.0mm ∅	4.5mm ∅
Numerical Aperture	0.01875	.0375	.075
Magnification	10X	20X	40X

∅ indicates diameter of object size

TABLE I

CONFIDENTIAL



OPTICAL SCHEMATIC

PAGE 5

SCALE 1:2

J-383
11-7-66

Sanitized Copy Approved for Release 2011/06/06 : CIA-RDP78B04747A002300080025-2

MECHANICAL DESIGN

The mechanical mounting and overall dimensions shown on Page 10 reflects the improvements made on the microscope.

The size has been reduced considerably from the original concept and all operating knobs are placed in positions which will allow the operator greater ease of operation than the original concept.

We have also incorporated an adjustable eyepiece assembly which can be raised or lowered to suit the height of the operator.

Two independent zoom systems are utilized in this microscope which can be operated independently or together. They can also be set for the various magnification within the 4 : 1 ratio individually and then operated together.

The dimensions shown on the outline drawing are what we believe we can maintain, however, any departure from the dimensions shown will not be to any great magnitude.

There are two principal modes of operation, the binocular microscope mode and the micro-stereoscope mode.

MECHANICAL DESIGN

When the binocular mode is used the image can be viewed through either arm, but only through one arm at a time.

A selector knob (shown on the mechanical drawing Page 10) permits the user to select the arm he wishes to view through.

This method was selected because it permits the user to switch from the micro-stereoscope mode to the binocular mode without changing the positions of this unit or re-focussing.

When using the unit as a micro-stereoscope, both arms are utilized, each viewing a separate image and each having its own optical path through to its respective eyepiece.

The arms can be moved in both X and Y co-ordinates without changing the position of the unit with respect to the light table for both modes.

Also in each mode of operation, the image may be rotated 360°. This is achieved optically and each optical path has its own rotating system.

The total separation in the micro-stereoscope mode is from 2 to 22 inches in the X direction and from 0 to 15 inches in the Y direction.

CONFIDENTIAL

MECHANICAL DESIGN

Co-ordinate directions are explained in the definition of terms on Page 1A.

Each of the arms carries a fixed 1X objective, mounted within the arm housing. These objectives are not removable.

Two 2X objectives and two 4X objectives are supplied. These objectives are threaded into the lower arm housing to achieve the desired magnifications. These objectives are removable.

Two 10X wide field eyepieces are supplied with the unit, which are used for both modes of operation.

Each eyepiece will contain its own eye guard to shield stray light. The eye guards can be rotated on the eyepiece to suit the comfort of the operator.

The eyepiece assembly, which contains the eyepieces, has an adjustment feature which allows the interpupilary distance to be varied between 54mm to 78mm.

Provisions have been made in this design to incorporate a polaroid film

CONFIDENTIAL

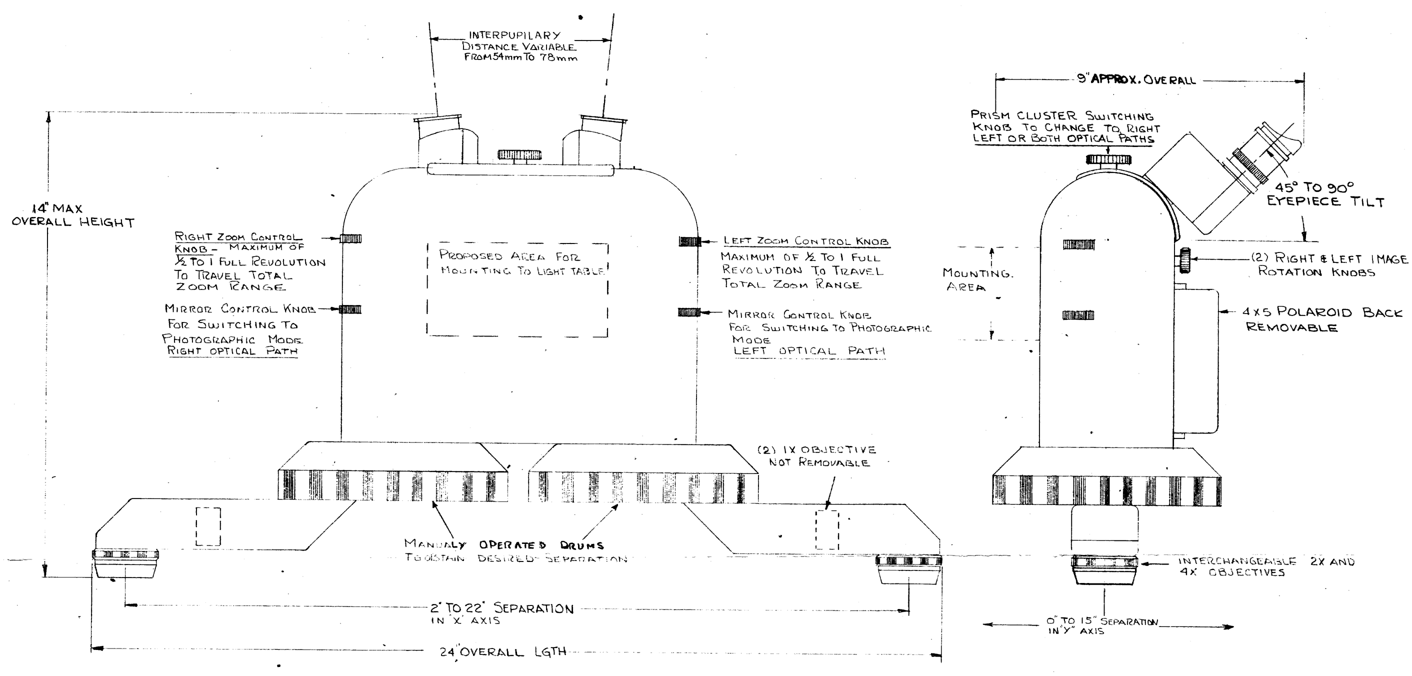
CONFIDENTIAL

MECHANICAL DESIGN

pack holder, which can be used to photograph the image in either mode.

In the binocular mode, the operator can select which optical path he wishes to photograph through and adjust the selector knob accordingly.

CONFIDENTIAL



NOTE: POSITION OF ALL CONTROL KNOBS SUBJECT TO APPROVAL OF CONTRACTING OFFICER

J-853
G.S. 11-13-66 LS

PAGE 10

SCALE 1:2 ≈

A. OBJECTIVES

For the objectives three alternatives were available. First, three interchangeable objectives working at the infinite conjugate position could be used to form a nearly parfocal system. One mirror would be interchangeable with the objectives. Since the exit pupil position from the zoom lens is the same for any objective, the 4X objective becomes exceedingly large. This in turn, makes the mirrors large and the arms themselves quite large. The second solution would be to bring the collimated light from the zoom system to a focus, insert a field lens, and use interchangeable parfocal relay systems. A system such as this will be extremely small and precisely parfocal. The difficulty, however, arises from the fact that the relay objectives become very fast. The 4X objective, for instance, would be approximately f/1.2. It is extremely difficult to design diffraction limited f/1.2 objectives with long conjugate distances, and likewise extremely expensive to manufacture them to the required precision. The interchangeable 2 X and 4 X objective system decided upon is not parfocal, varying in working distance from three inches to approximately 1/2 inch. The main advantages are that no mirror must be interchangeable and the 1X objective is used to reduce the size of the 2X and 4X objectives. This, of course, will be rather easily manufactured. It also resembles the well known Lister microscope objective and lends itself to a known systematic design proceedure.

CONFIDENTIAL

B. ZOOM SYSTEM

The zoom system was initially a strictly focal symmetrical type five component optically compensated relay. The basic first order properties of this zoom system have been maintained throughout the design. By replacing the dove prism with a new derotation prism system, the need for collimated light was eliminated and one component of the zoom system was removed, permitting the light to come to a focus. The image is transferred by the means of a relay lens, to the eyepiece focal plane. Figure 2 on Page 31 shows a plot of the zoom magnification versus the drift in focus in numbers of focal ranges. Also shown in the plot is the out of focus condition in focal ranges as a function of magnification when the lens is two focal ranges out of focus at the high magnification position.

CONFIDENTIAL

C. Relay

In addition to the size reduction, the use of a relay lens provides two additional distinct advantages.

One, the exit pupil position presented to the eyepiece is strictly constant. It is a very desirable characteristic that the position of the eye in relation to the eyepiece is a constant for any given zoom magnification. The lack of fulfilling this condition is obvious when eyecups or headrests are used. Since an aperture stop is placed at the relay lens, the condition of constant exit pupil position is rigidly observed.

The second advantage of the intermediate relay is that the aperture stops can be an iris diaphragm, thus providing the means to stop down the system. This can be very desirable when viewing low spatial frequency, very low contrast objects.

D. FIELD LENS

The field lens serves two purposes. First, it relays the exit pupil of the zoom system to the relay lens. Secondly, it is a hyperchromatic doublet correcting for a small, residual lateral color resulting from the zoom system. Since the crown and flint glass of this field lens are reversed from the normal positive doublet, the resulting field curvature is considerably less than the singlet field lens alone.

CONFIDENTIAL

E. CAMERA LENS

The camera lens picks up the intermediate image formed by the zoom lens and relays this image to the Polaroid Film pack adapter at approximately 20X magnification.

This lens will be a short focal length lens and since the angular coverage and aperture are both small, there will be no difficulty in achieving a diffraction limited system.

CONFIDENTIAL

IMAGE QUALITY

The first step in determining the performance of the design is to ray trace the system and plot the conventional H Tan U or rim ray curves. Each of the curves plotted represents the deviation H from an ideal image point, as the ordinate plotted against the tangent of the angle that the ray makes with the optical axis in the image plane. In actual practice the abscissa is the difference of tangents of the ray and the chief ray (that ray which passes through the center of the entrance pupil of the lens). Thus Δ Tan U$'$= 0 for the chief ray from any particular object point.

In addition to the tangential or meridional rays discussed above, the saggital or skew ray deviations are plotted as a function of their final angle made with the Y-Z plane. Because of the symmetry about the Y-Z plane, only one-half of the saggital fan is traced.

It can be shown that the slope of each curve through its respective origin is a direct measure of the focal position deviation from the paraxial image plane. These slopes thus represent field curvature, and the difference between saggital and the tangential slopes at a particular object point is a measure of astigmatism.

The symmetrical deviations of the curve from a straight line tangent to the curve at the origin are a measure of transverse spherical aberration. The assymetrical deviations from this same line are a measure of coma. Thus a perfect lens would be plotted as a family of straight lines with zero slope.

Since the ordinate is a direct measure of the blur circle in the paraxial image plane, a fairly good prediction of contrast and resolution can be made by study of these plots. Of greater value is that it is apparent which aberrations are affecting image quality. This enables the lens designer to determine what needs to be corrected, whether it can be corrected with the present basic optical configuration, and how to proceed.

Figure 3 shows the high contrast resolving power as predicted from the H Tan U plots. The Airy disk spot size criteria was used as a basis for determining diffraction effects.

Since the 1X objective balances some residual aberrations of the zoom system, and the 2X and 4X objectives are essentially aberration free, the image quality characteristics remain fairly constant for all three objectives. Therefore, the axial and field performance variations will be discussed as a function of zoom position.

First, the axial image quality at the 4X zoom position is essentially diffraction limited. The spherical aberration is well corrected with the only residual being slight spherochromatism and dominant secondary color. The result of the secondary color will be the usual purple imaging of black objects with a surrounding, yellowish-green haze. This condition is eliminated in apochromatic systems and greatly reduced in semi-apochromatic systems. At the 2X zoom position the axial spherical aberration is overcorrected. This overcorrection will result in a loss of contrast at high frequencies, but not enough of a loss to cause failure to meet the 5 lines per millimeter, per power resolving powers specifications. Again the secondary chromatic aberration is dominant and will cause purple imaging of black targets. At the 1X zoom position the spherical aberration is again corrected to a residual of nearly zero. The secondary chromatic aberration is far larger than the residual spherical aberration. There should be no problem imaging even the higher frequencies at high contrast.

At the 4X zoom position the edge of the field suffers from some saggital spherical aberration, slight coma, and astigmatism. The astigmatism will cause some deterioration of the image quality. Going to the 2X zoom position, the astigmatism and coma completely disappear. The resulting image is as good at the edge of the field as it is on axis. At the 1X zoom position, the coma reappears along with slight astigmatism. Again, the image quality will deteriorate somewhat.

As previously explained, the lateral color is completely removed by the hyperchromatic field lens.

The camera objective is essentially diffraction limited over its entire field. Since the f/number is so large, there will be no variations of aberrations due to the other part of the system, and was thus evaluated with an unaberrated object. As can be seen by the aberration plot, the image on film will be as good as that in the eyepiece focal plane.

PREDICTED HIGH CONTRAST RESOLVING POWER
USING 10X WIDE FIELD EYEPIECE

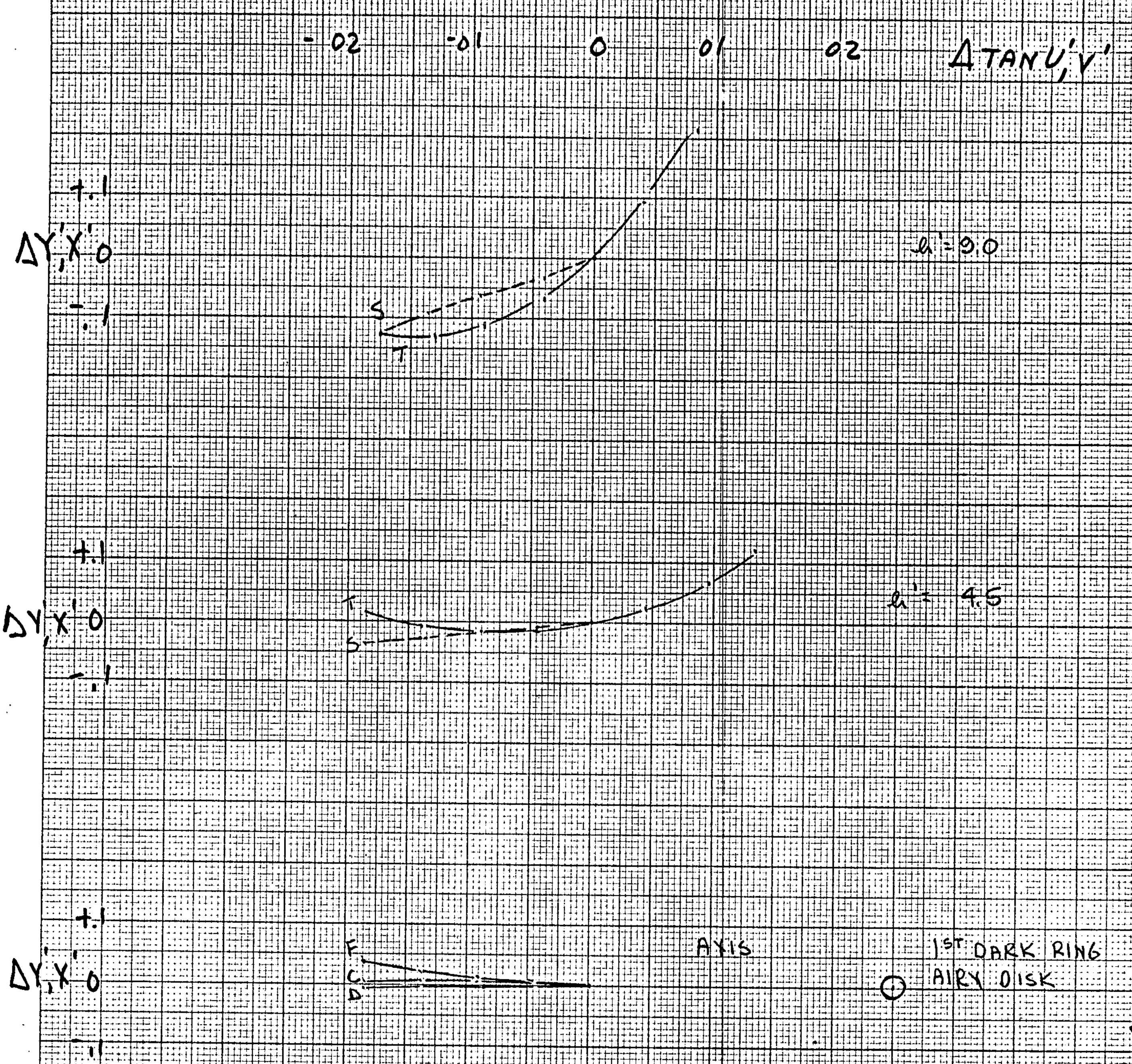
	Axis	.5 Field	.7 Field	1.0 Field
1X OBJECTIVE				
1X Zoom	50	50	30	10
2X Zoom	100	80	70	50
4X Zoom	200	200	150	100
2X OBJECTIVE				
1X Zoom	100	75	60	50
2X Zoom	200	200	200	200
4X Zoom	400	350	300	300
4X OBJECTIVE				
1X Zoom	200	150	50	50
2X Zoom	400	400	400	400
4X Zoom	900	600	550	450

IN LINE PAIRS/mm.

Fig. 3

12-188

/X OBJECTIVE, /X ZOOM

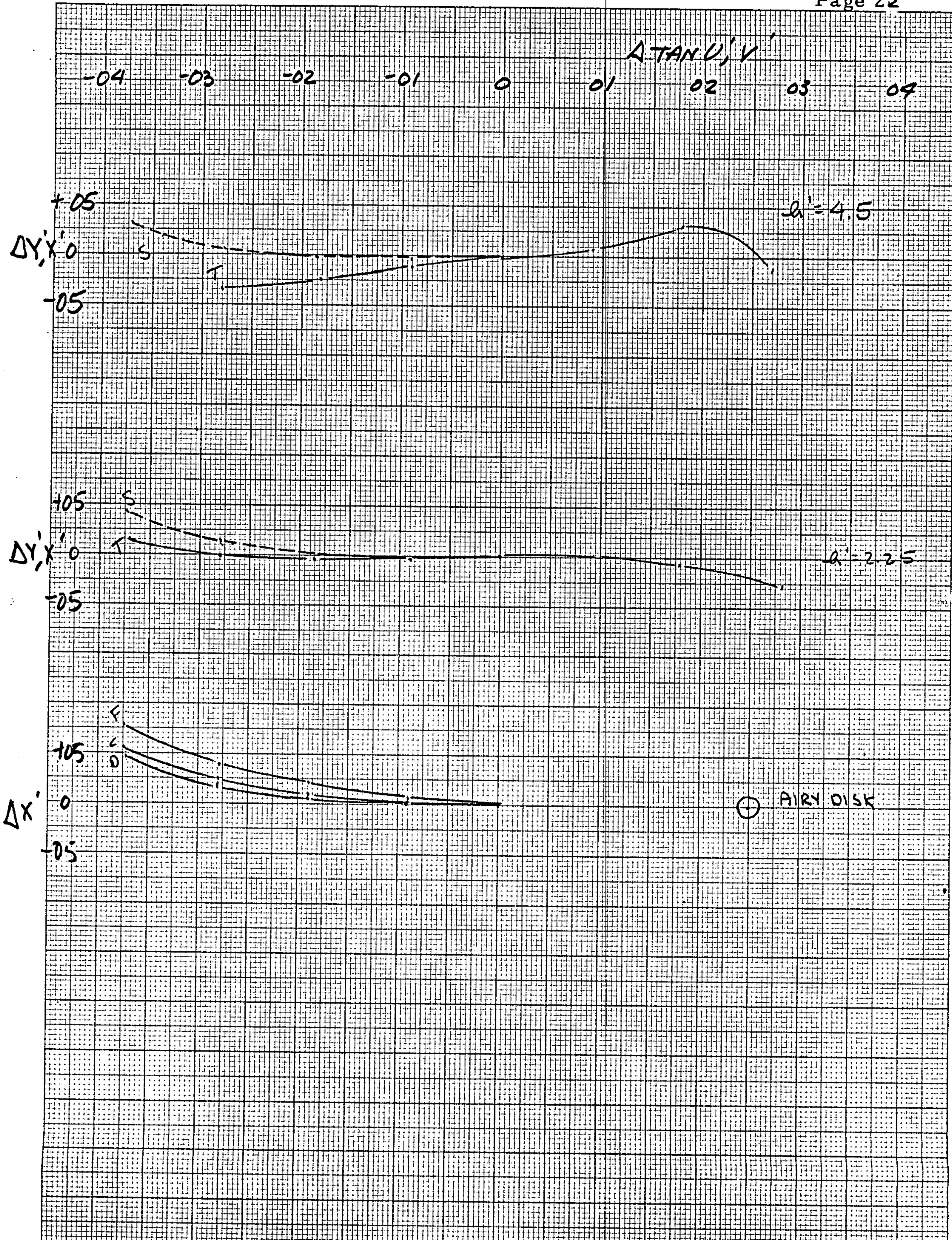


10 Millimeters to the Centimeter

CONFIDENTIAL

12-188

1X OBJECTIVE, 2X ZOOM

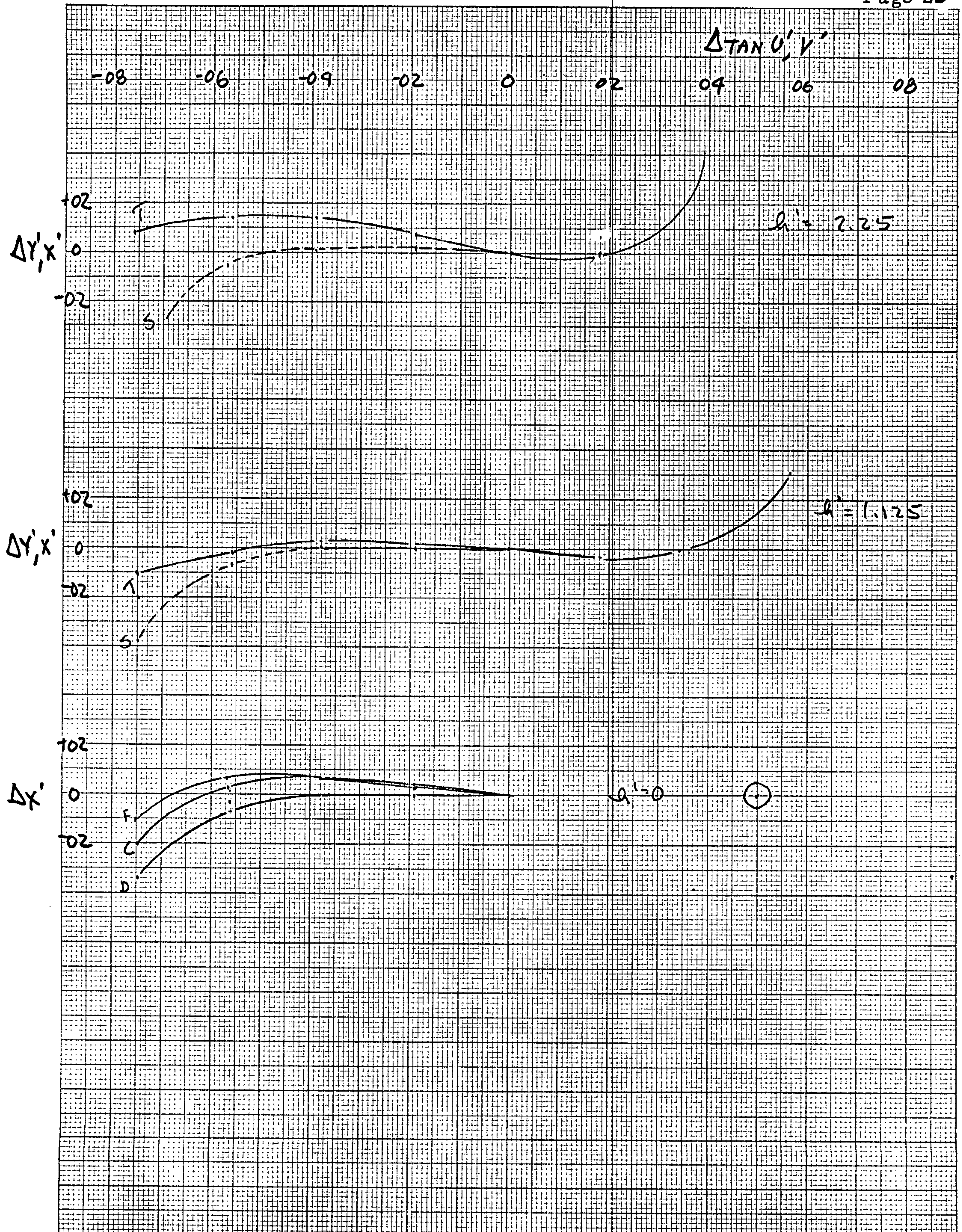


CONFIDENTIAL

10 Millimeters to the Centimeter

12-188

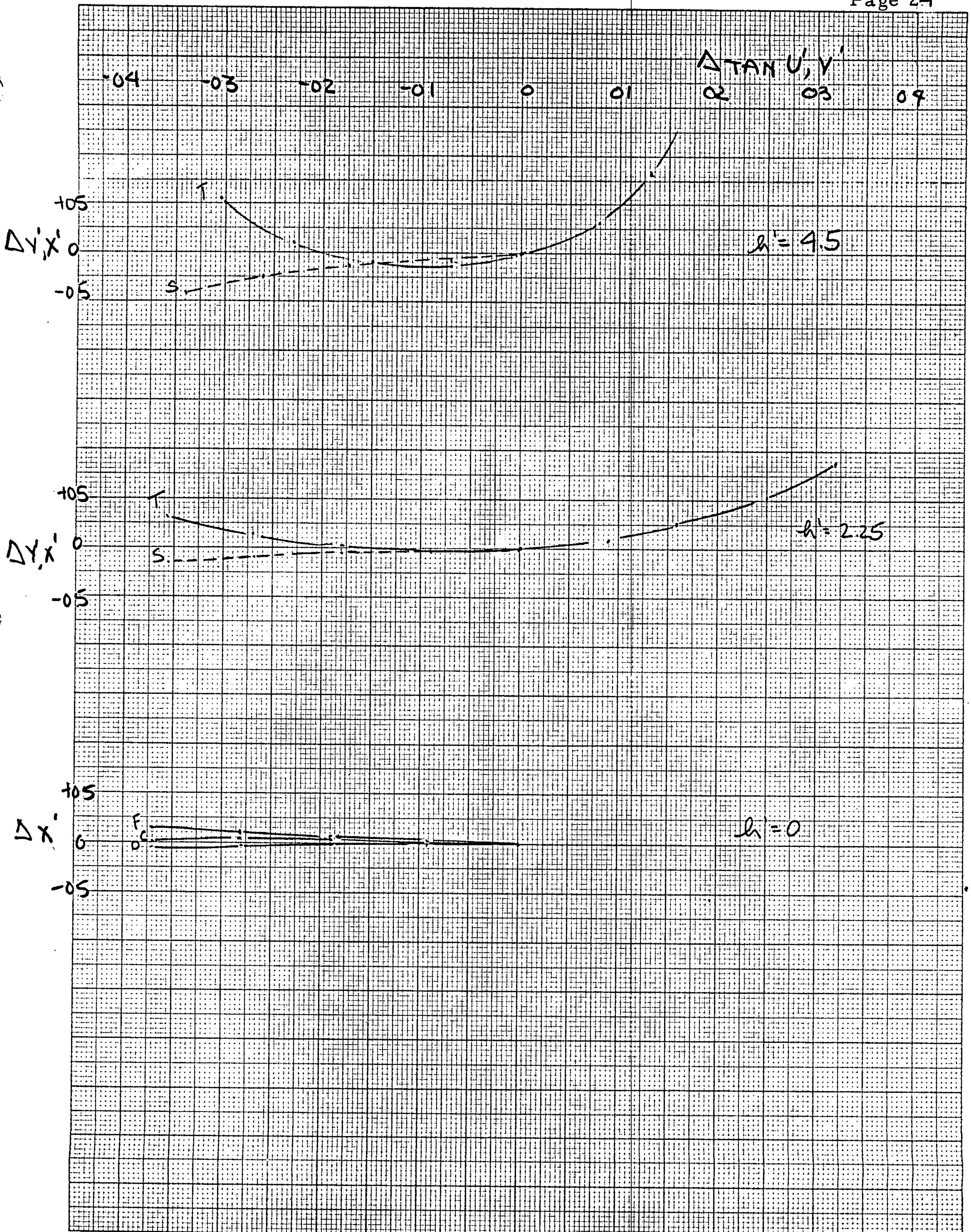
/X OBJECTIVE , 4X ZOOM



CONFIDENTIAL

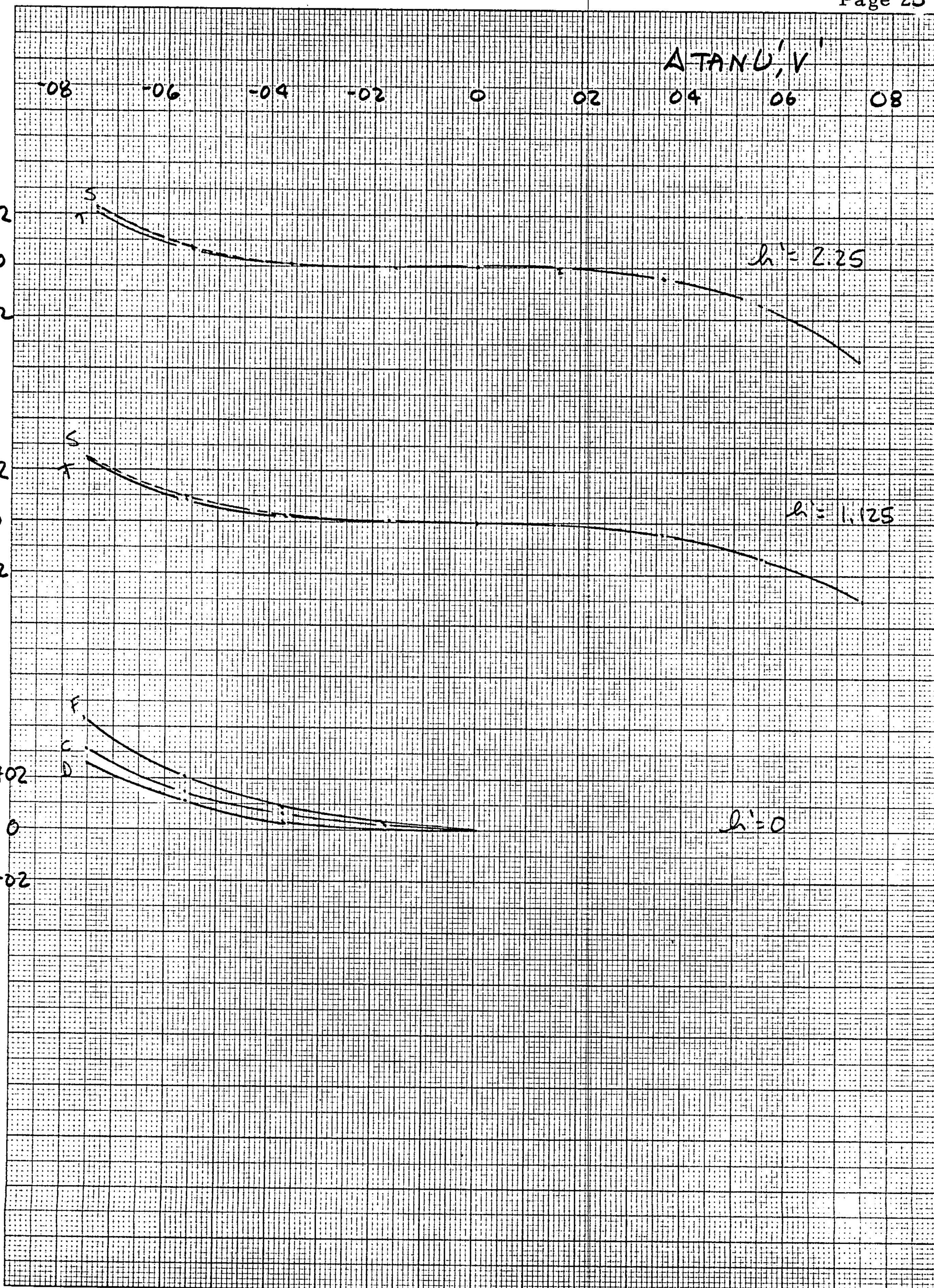
12-188

2X OBJECTIVE 1X Zoom



CONFIDENTIAL

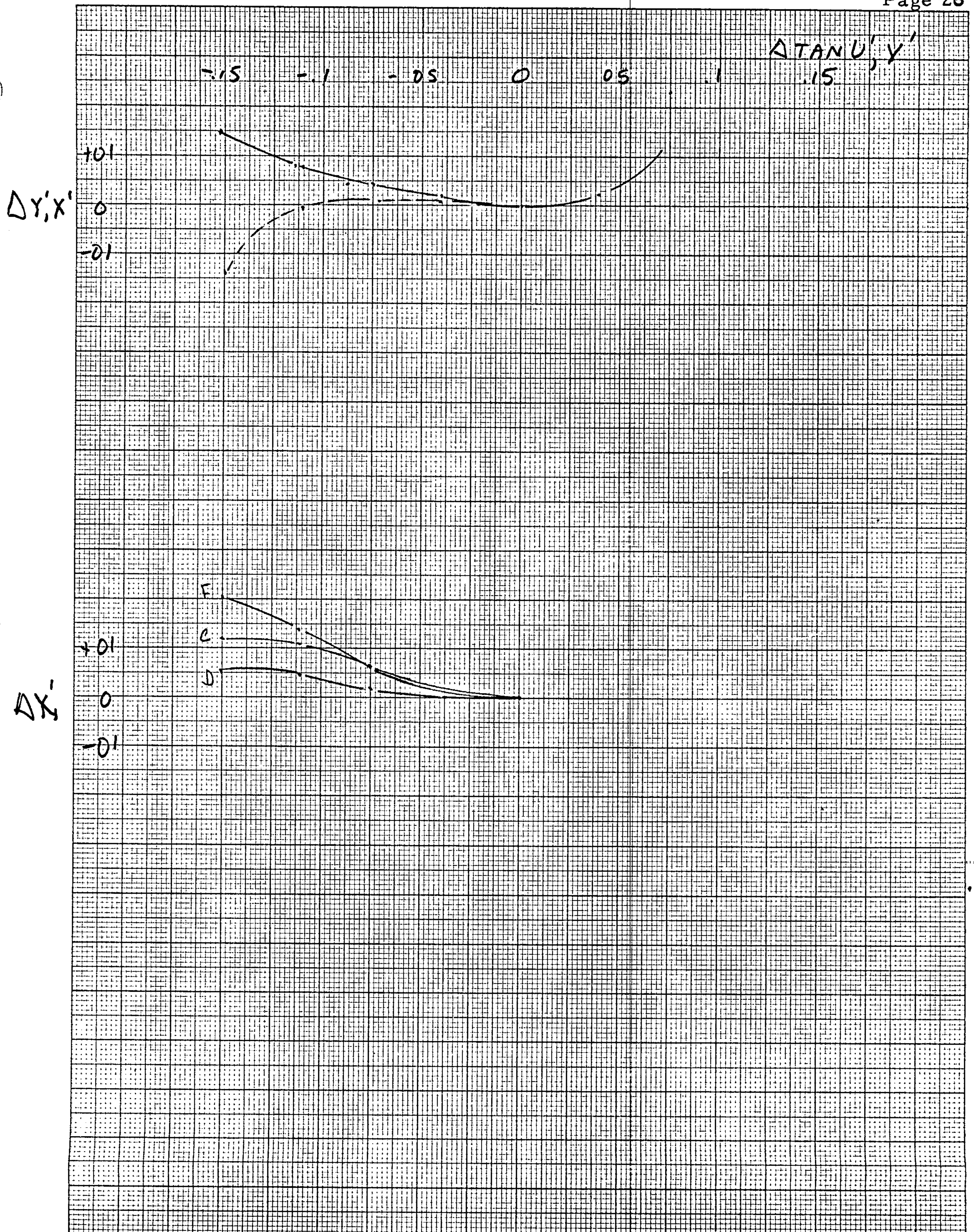
10 Millimeters to the Centimeter



Sanitized Copy Approved for Release 2011/06/06 : CIA-RDP78B04747A002300080025-2

12-188

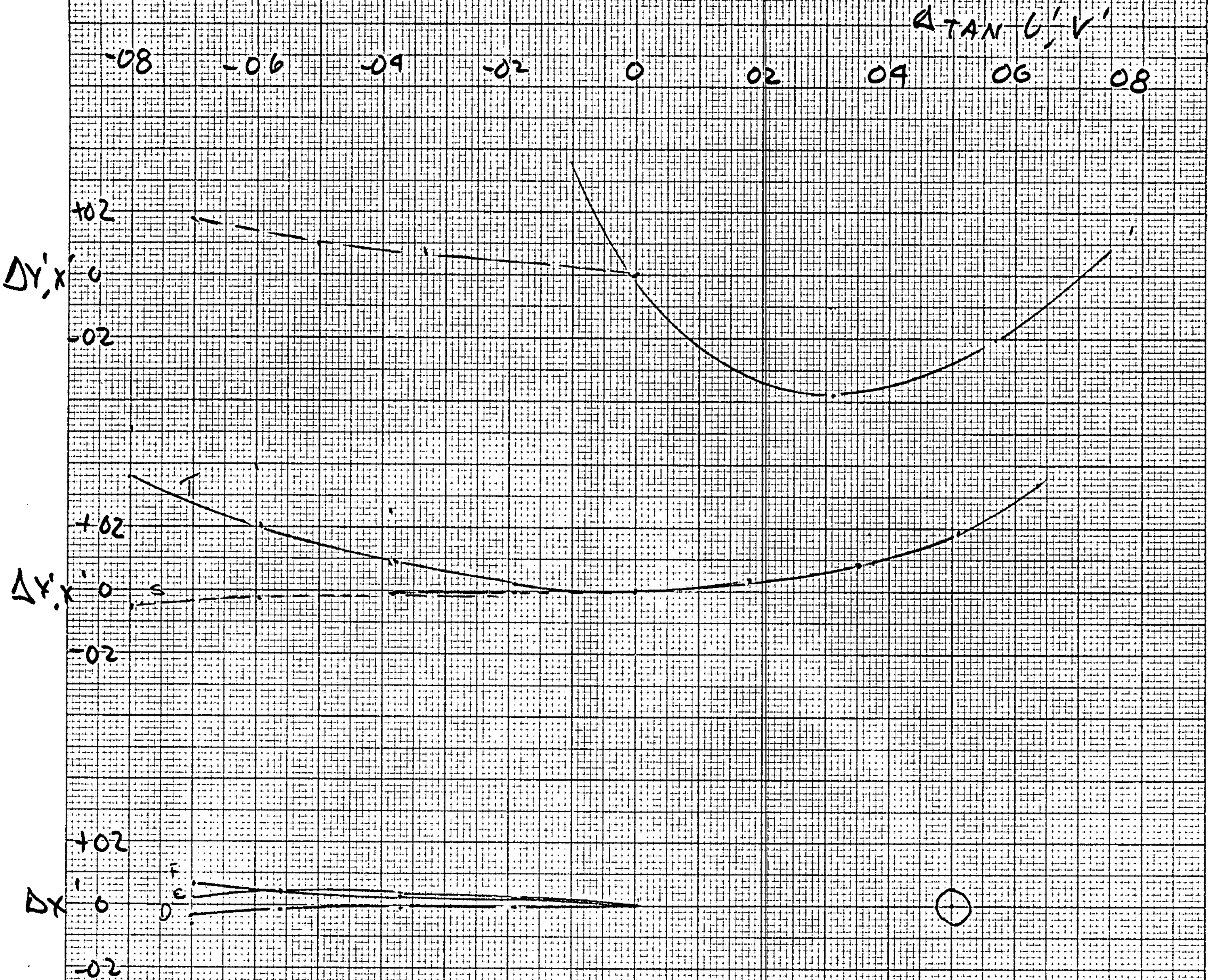
2X OBJECTIVE, 7X ZOOM



10 Millimeters to the Centimeter

CONFIDENTIAL

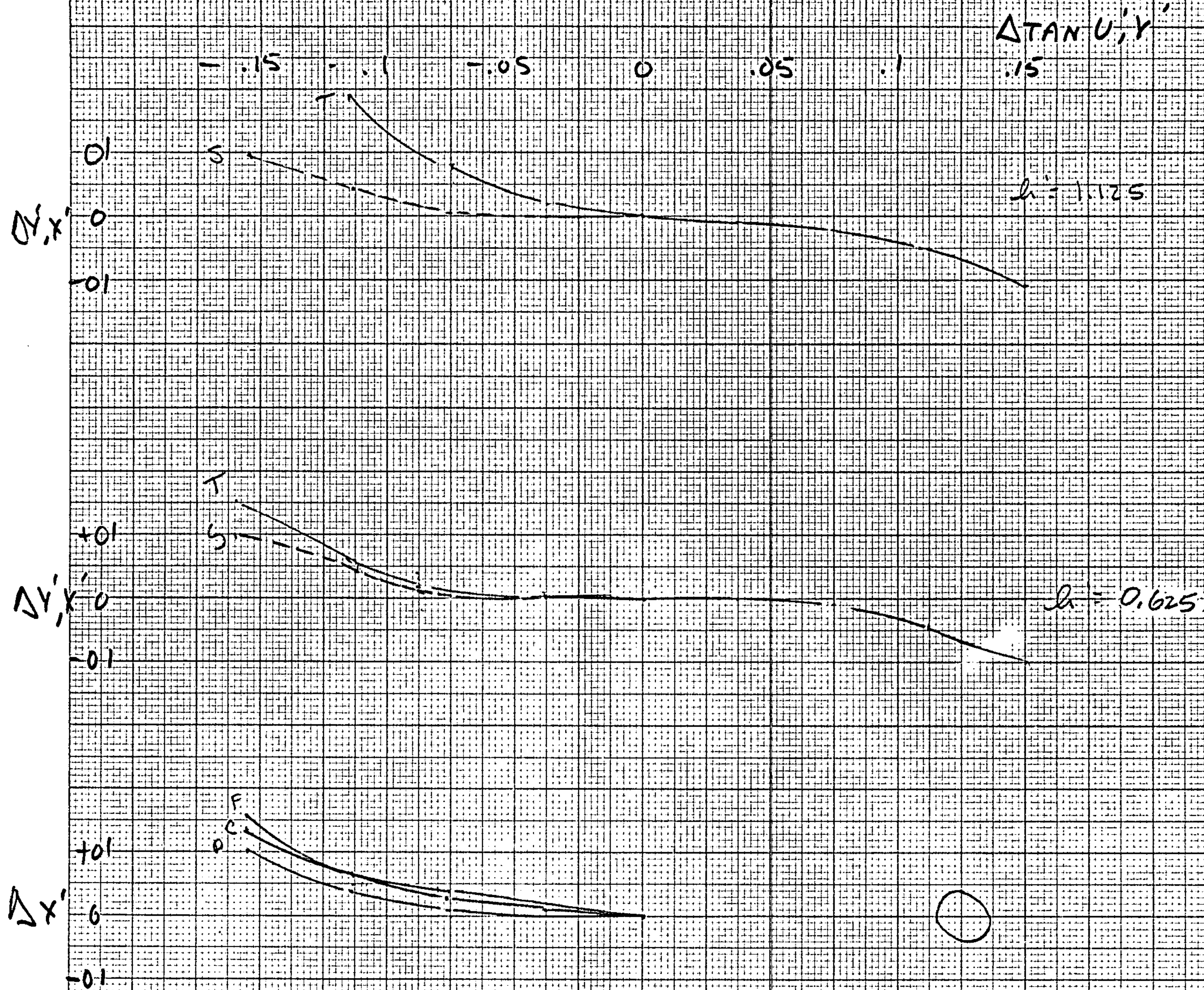
4X OBJECTIVE, 1X ZOOM



CONFIDENTIAL

Sanitized Copy Approved for Release 2011/06/06 : CIA-RDP78B04747A002300080025-2

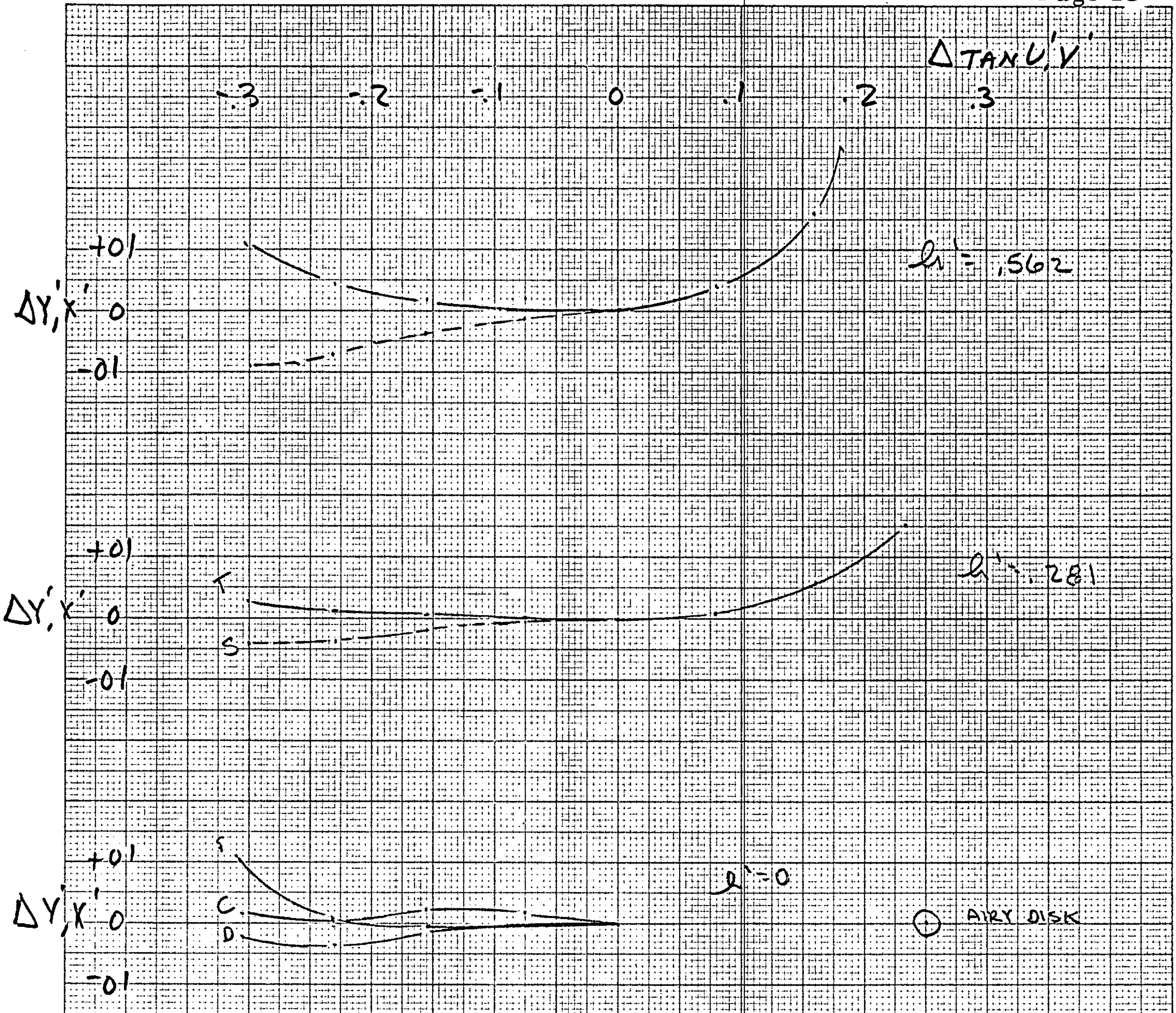
12-188



10 Millimeters to the Centimeter

12-188

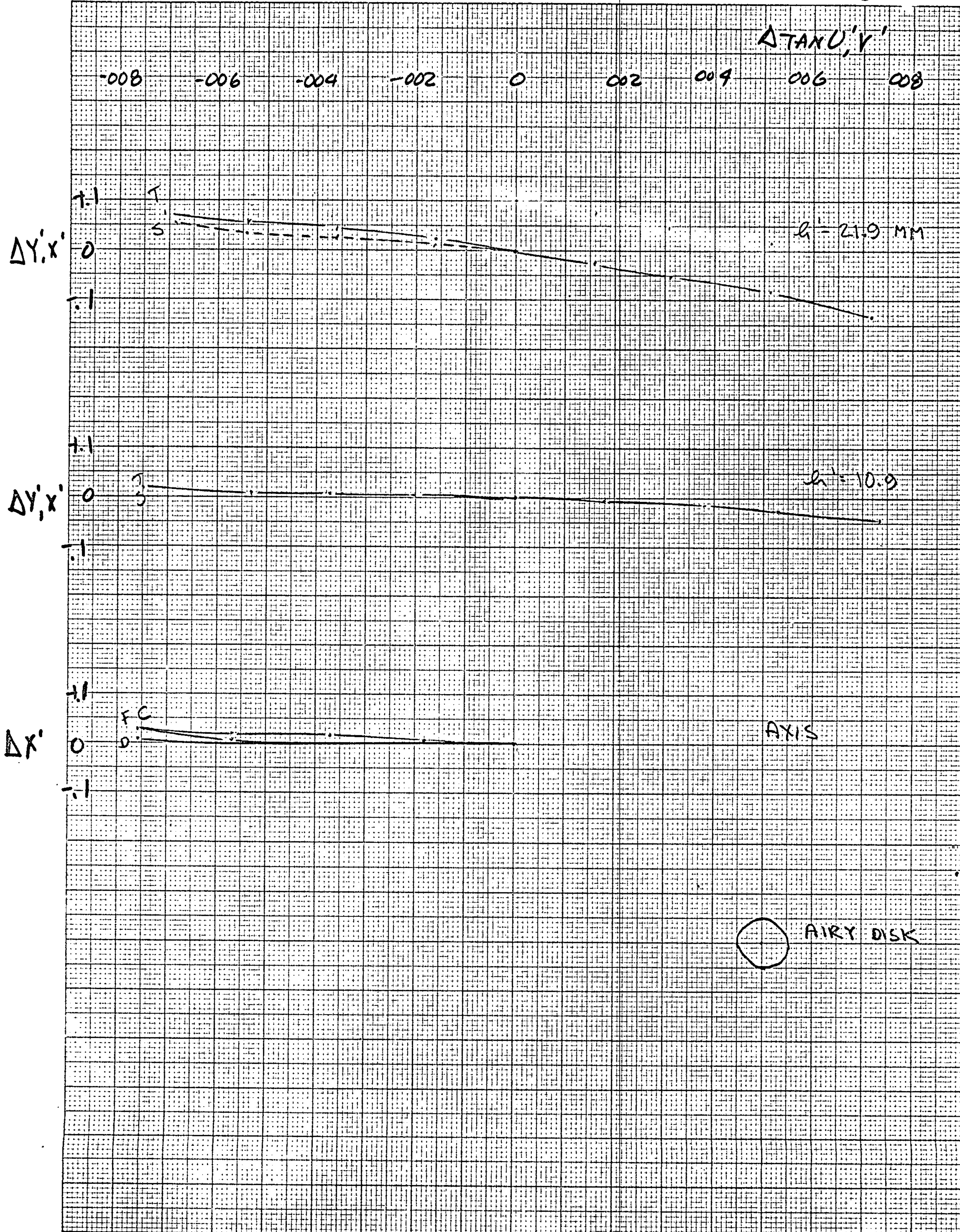
4X OBJECTIVE, 4X ZOOM



10 Millimeters to the Centimeter

CONFIDENTIAL

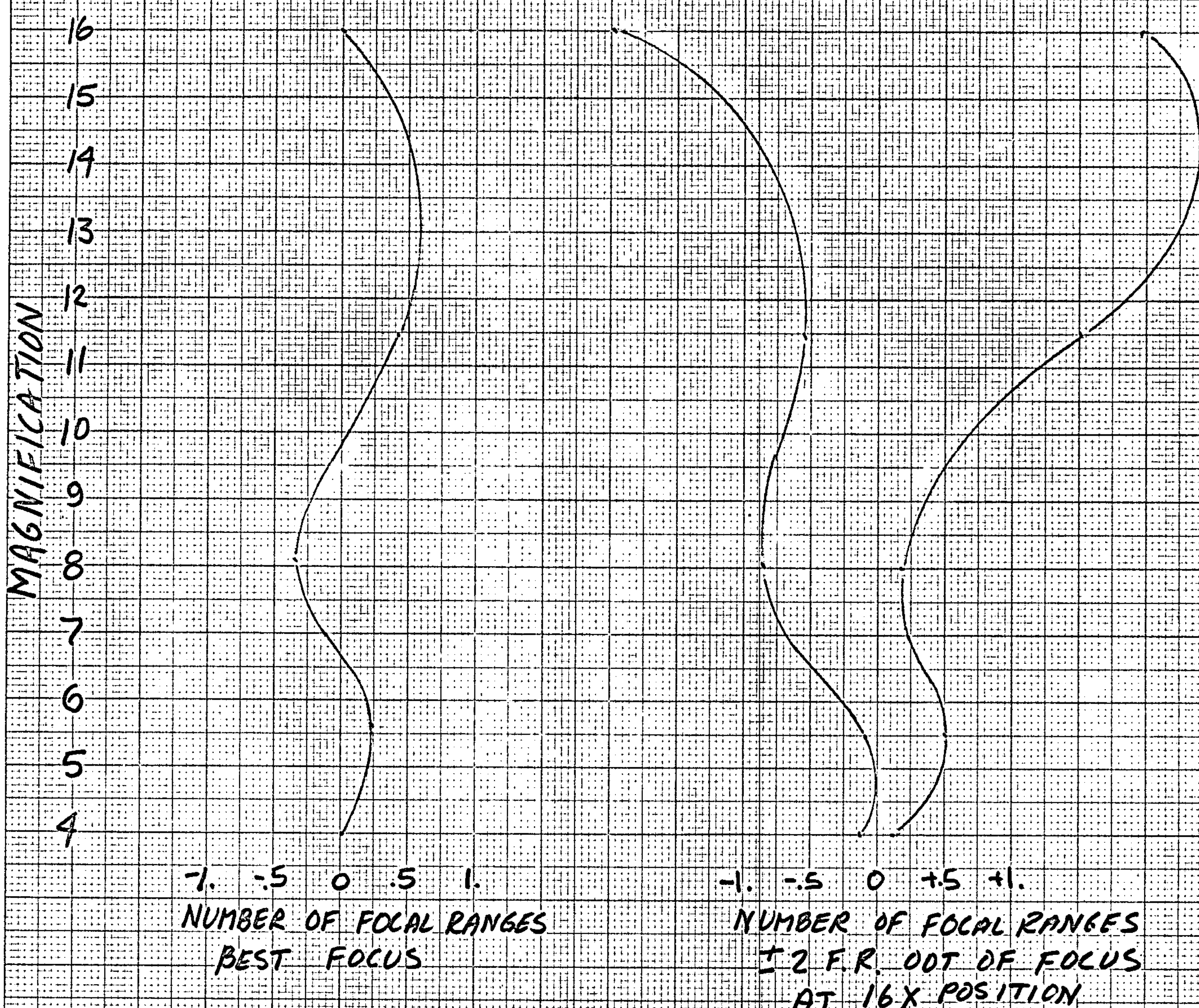
12-188



10 Millimeters to the Centimeter

CONFIDENTIAL

FOCAL SHIFT WITH 4X OBJECTIVE

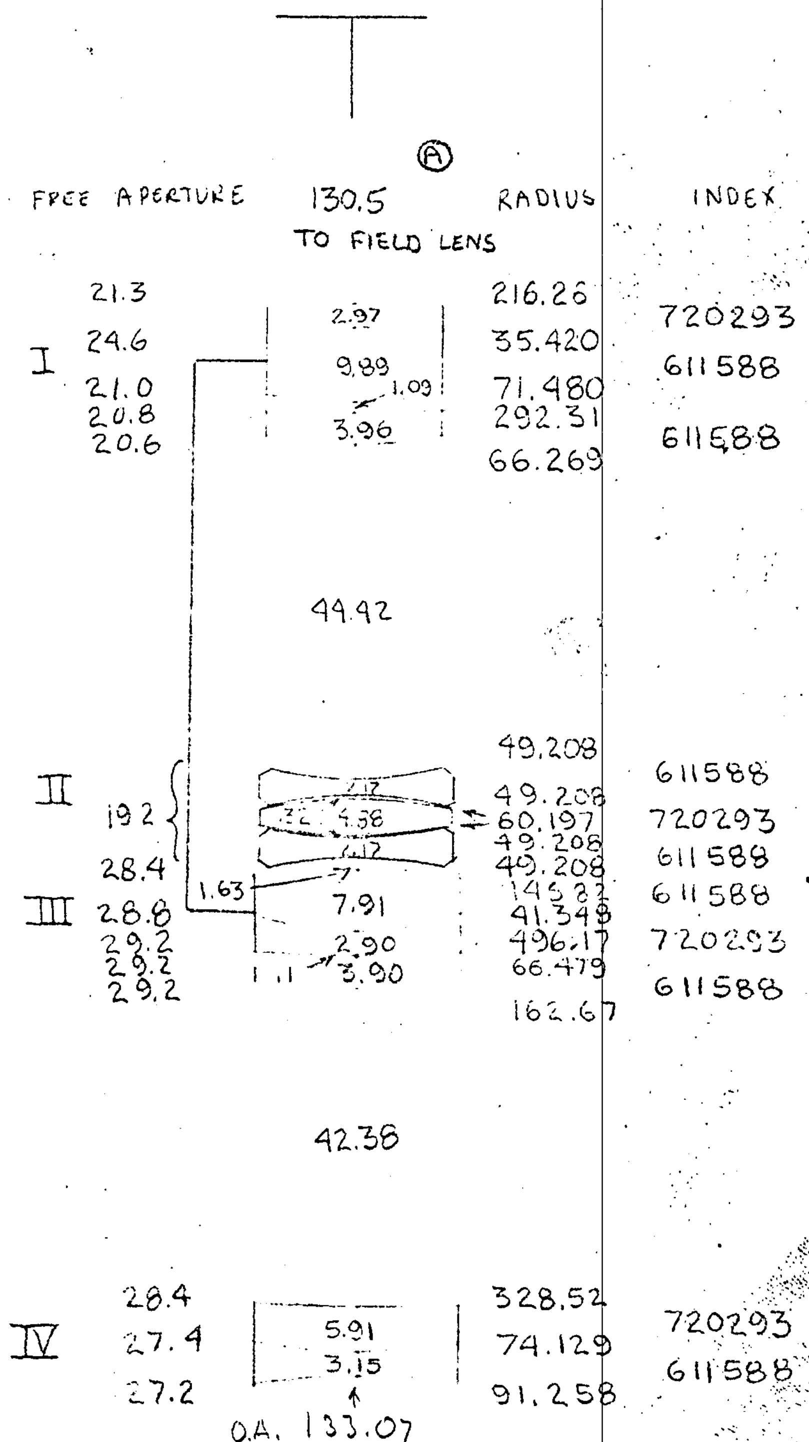


$$1 \text{ FOCAL RANGE} = \lambda/(N.A.)^2$$

FIG. 2

BY EB DATE 7-2-66 SUBJECT STEREO ZOOM MICROSCOPE ZOOM COMPONENT SHEET NO. ____ OF ____

CHKD. BY ____ DATE ____ JOB NO. 03-853



A WAS 135.5 TO IMAGE CHANGED 7-19-66 EB

THE COMBINED LENS I & III MOTION IS 39.24 FOR 4X ZOOM POSITION. FOR 1X THE MOVEMENT IS 19.62. DRAWING IS AT 1X POSITION

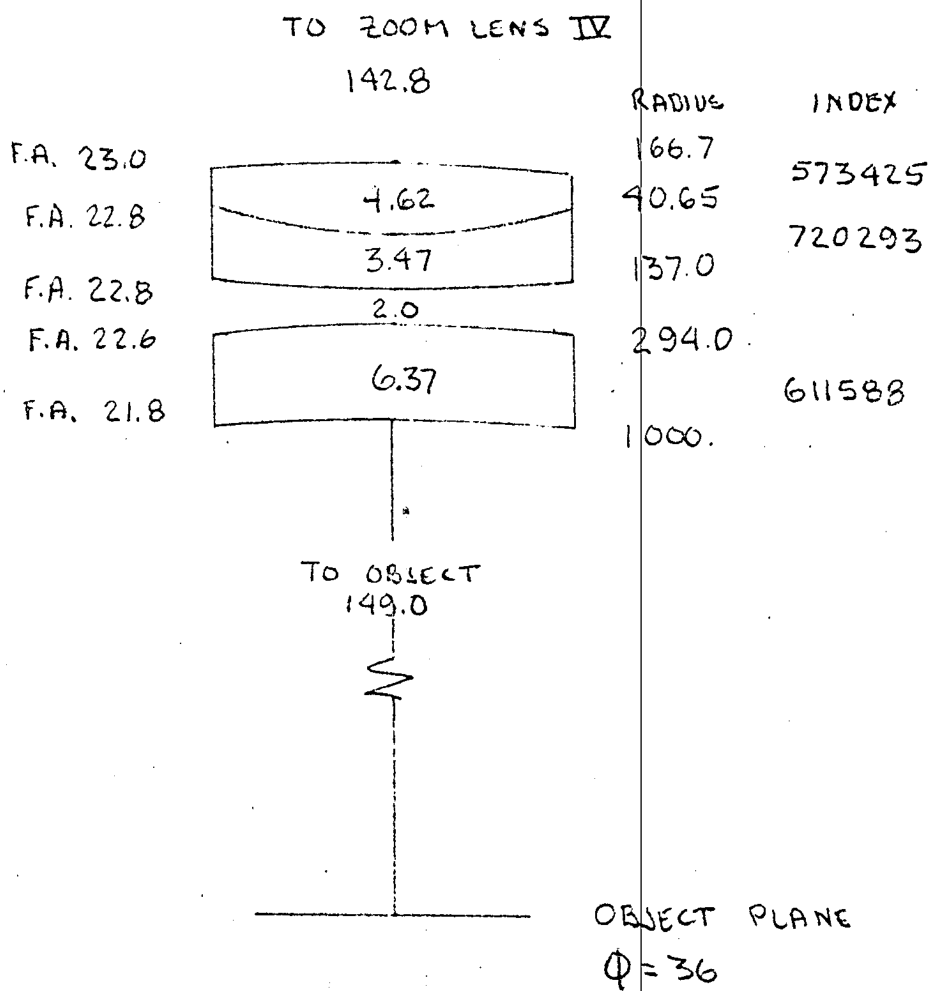
25X1

CONFIDENTIAL

BY EB DATE 7-19-66 SUBJECT STEREO MICROSCOPE SHEET NO. OF

CHKD. BY DATE 1x OBJECTIVE JOB NO. 03-853

CONFIDENTIAL



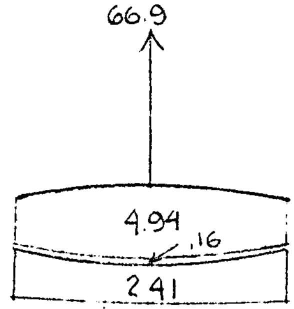
CONFIDENTIAL

25X1

BY EB DATE 7-19-66 SUBJECT STERO ZOOM MICROSCOPE 2X OBJECTIVE SHEET NO. OF

CHKD. BY DATE JOB NO. 03-853

TO 1X OBJECTIVE
66.9



		RADIUS	INDEX
FA. 18.4		48.40	611588
F.A. 18.2	4.94	48.40	
F.A. 17.4	.16	40.16	
F.A. 17.4	2.41	138.9	720293

35.1 WORKING DISTANCE

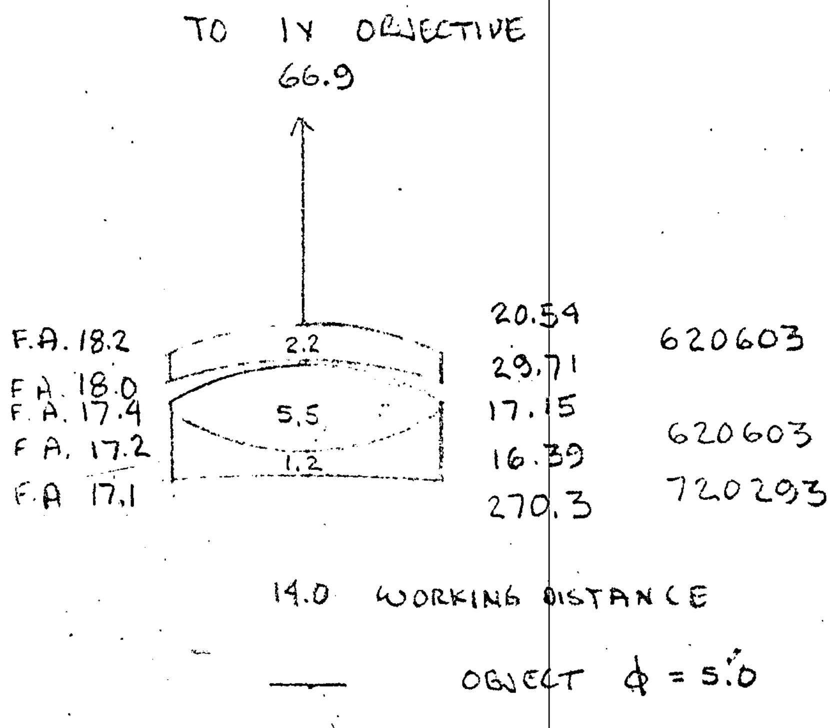
ϕ = 9.0 OBJECT PLANE

25X1

CONFIDENTIAL

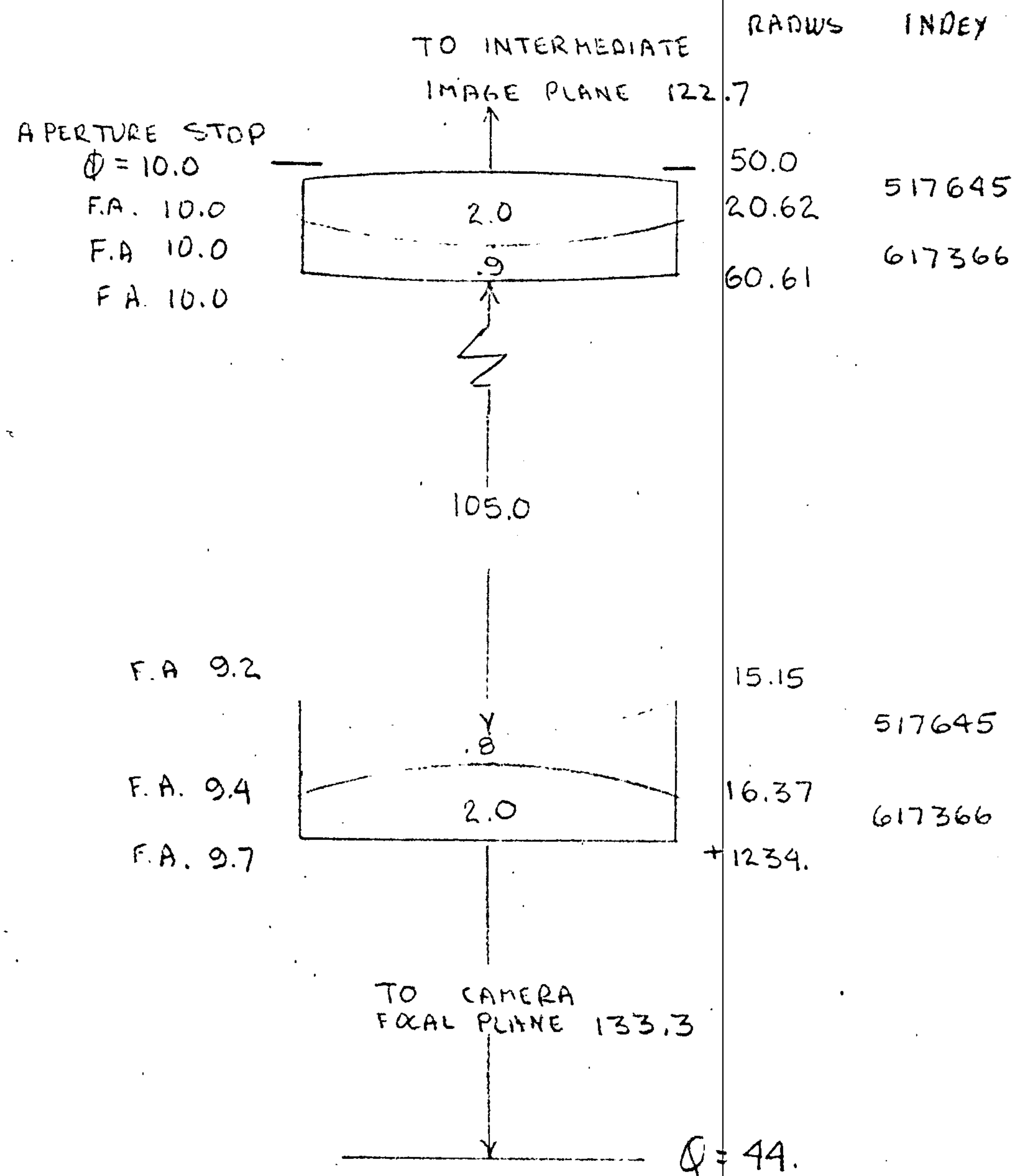
Sanitized Copy Approved for Release 2011/06/06 : CIA-RDP78B04747A002300080025-2

BY ER DATE 7-19-66 SUBJECT STEREO ZOOM MICROSCOPE SHEET NO. 7 OF 8
CHKD. BY ______ DATE ______ 4X OBJECTIVE JOB NO. 03-853



CONFIDENTIAL

BY E.B. DATE 7-18-66 SUBJECT STEREO ZOOM MICROSCOPE CAMERA OBJECTIVE SHEET NO. ... OF ...
CHKD. BY ... DATE ... JOB NO. 03-853



EFL = 29.4

MAGNIFICATION 5.25 X

CONFIDENTIAL

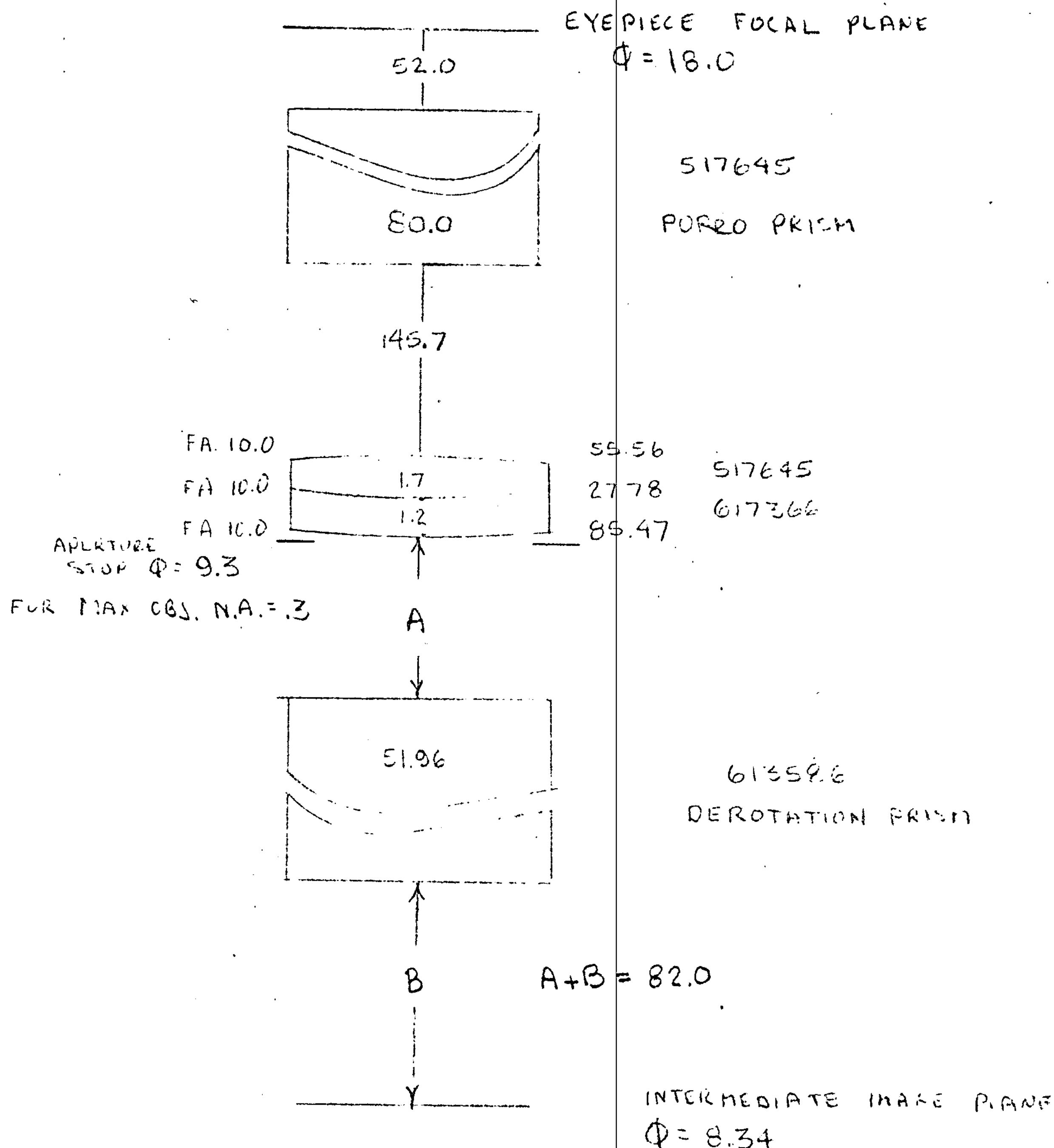
25X1

BY C.K. DATE 7-19-66 SUBJECT STEREO ZOOM MICROSCOPE RELAY SYSTEM

CHKD. BY ...... DATE ......

SHEET NO. ...... OF ......

JOB NO. 03-853



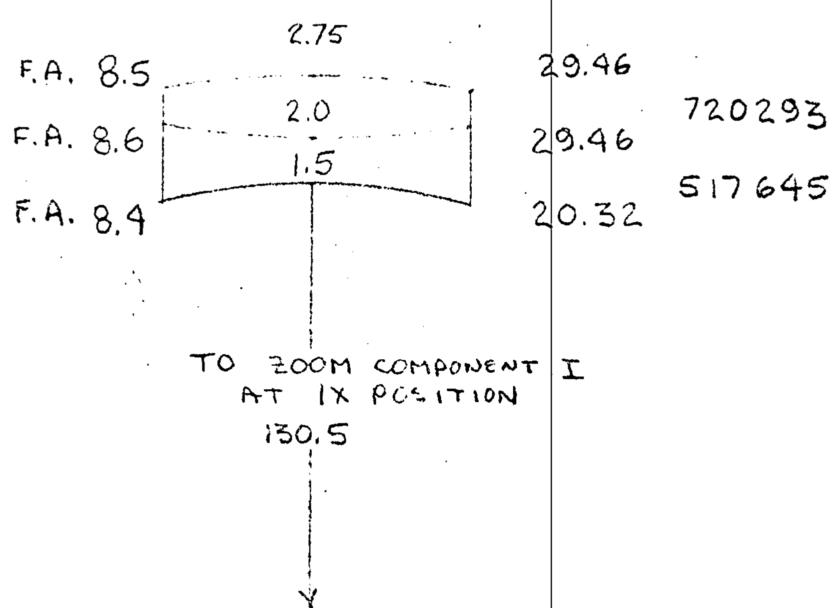
25X1

CONFIDENTIAL

BY EG DATE 7-1966 SUBJECT STEREO ZOOM MICROSCOPE FIELD LENS SHEET NO. OF

CHKD. BY DATE JOB NO. 03-853

INTERMEDIATE IMAGE $\phi = 8.34$



25X1

CONFIDENTIAL

CONFIDENTIAL

SUMMARY

The design submitted represents the original intent of the contract and the additional changes made [redacted] 25X1

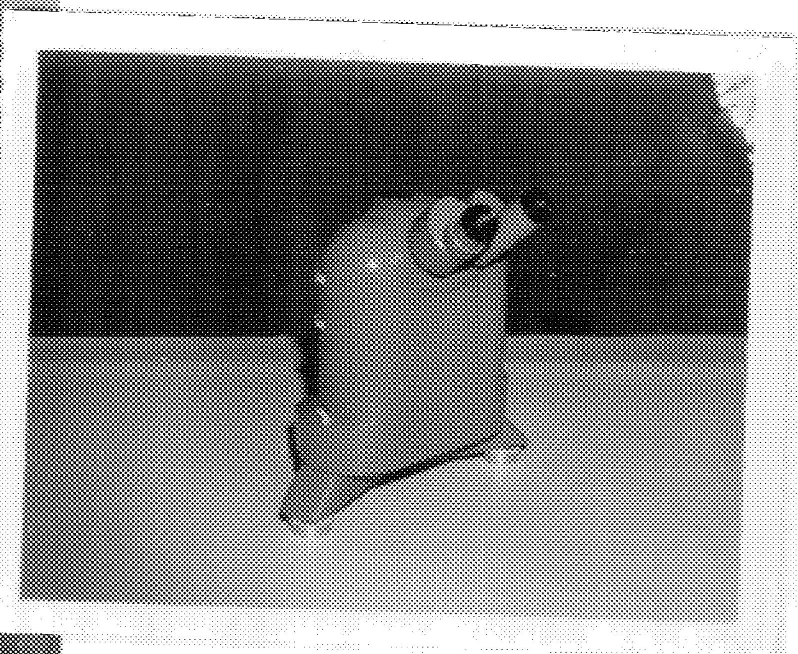
[redacted] 25X1

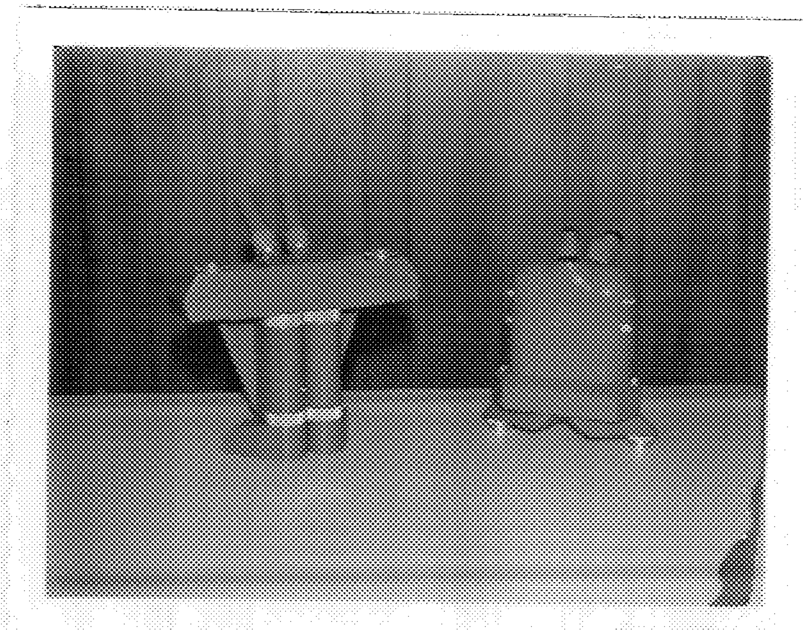
The addition of a Polaroid camera back and the greater coverage that can be obtained by the separation of the arms and the tilting eyepiece assembly are three of the features that were not part of the original contract.

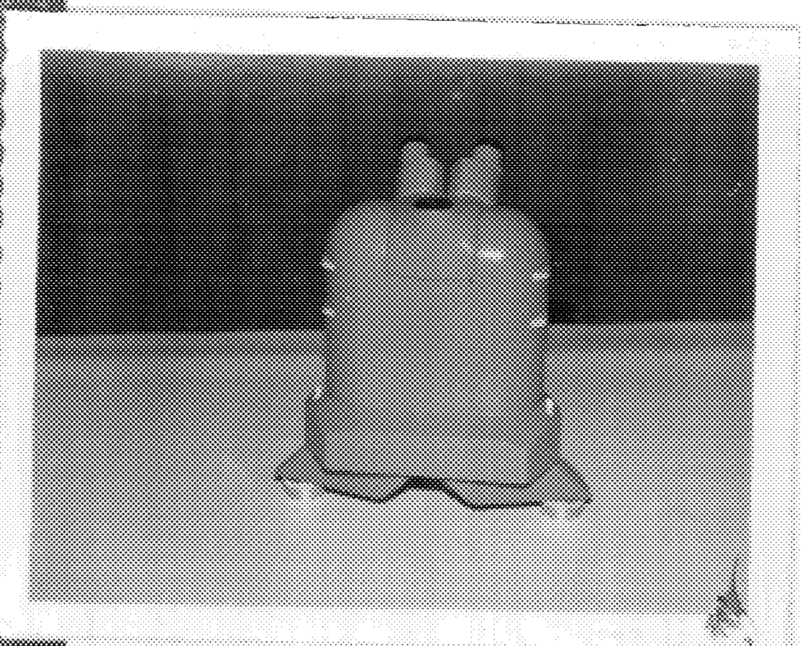
We feel that this unit will be extremely easy to operate and can be manufactured in quantity with little or no difficulty.

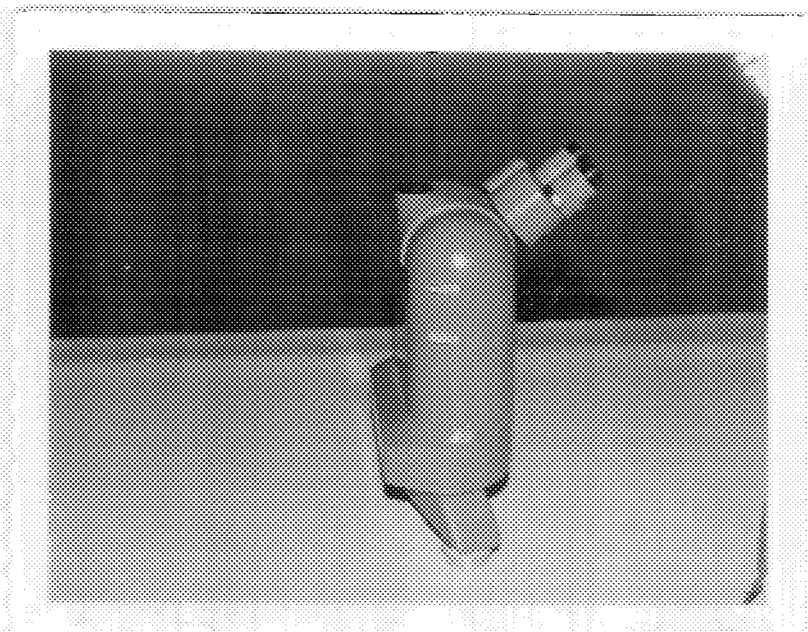
CONFIDENTIAL

Sanitized Copy Approved for Release 2011/06/06 : CIA-RDP78B04747A002300080025-2









Sanitized Copy Approved for Release 2011/06/06 : CIA-RDP78B04747A002300080025-2

CONFIDENTIAL

Micro-Stereoscope and Binocular Microscope

[redacted] 25X1

Design Phase I

Sanitized Copy Approved for Release 2011/06/06 : CIA-RDP78B04747A002300080025-2